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CEER Paper on Whole System Approaches

Distribution Systems Working Group

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Council of European Energy Regulators asbl
Cours Saint-Michel 30a, Box F – 1040 Brussels, Belgium
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Abstract

This document (C19-DS-58-03) presents a short paper on Whole System Approaches (WSA). This document seeks to support energy regulators' and stakeholders' discussions on regulatory approaches that consider the societal net benefit for the entire system (the so-called Whole System Approaches) and encourage network operators to consider consequences of their decisions on other actors of the value chain.

It categorises three different layers of Whole System Approaches, taking into account the parties involved (network operators and others) and the scope of activities impacted: "whole-network-approach" (layer 1), "whole-chain-approach" (layer 2) and "cross-systems-approach" (layer 3).

Annex 1 presents some case studies with practical application of WSA showing that some regulators have already adopted elements of the WSA and that the WSA has evolved based on the assessments of former mechanisms.

Target audience

National Regulatory Authorities, gas/electricity industry, consumer representative groups, network operators, Distribution System Operators (DSOs), Transmission System Operators (TSOs), academics and other interested parties.

Keywords

Whole system approach, network regulation, incentives, transmission system operation, distribution system operation, network operation, network planning, sector coupling, energy system integration.

If you have any queries relating to this paper, please contact:

CEER Secretariat
Tel. +32 (0)2 788 73 30
Email: brussels@ceer.eu

Related documents

CEER Documents

- ACER – CEER, The Bridge Beyond 2025 Conclusions Paper, 19 November 2019.
- CEER Guide to Bundled Products, 6 November 2019, Ref. C19-PEER-07-06.
- CEER Conclusions Paper on Dynamic Regulation to Enable Digitalisation of the Energy System, 10 October 2019, Ref: C19-DSG-09-03
- CEER Conclusions Paper on New Services and DSO Involvement, 22 March 2019, Ref. C18-DS-46-08.
- CEER Conclusions Paper on Incentives Schemes for Regulating Distribution System Operators, including for innovation, 19 February 2018, Ref: C17-DS-37-05.
- CEER Public Consultation on Incentives Schemes for regulating DSOs, including for Innovation, January 2017, Ref: C16-DS-28-03
- CEER Position Paper on the Future DSO and TSO Relationship, September 2016, Ref: C16-DS-26-04.

Other documents

- ENTSO-E, 3rd ENTSO-E Guideline for Cost Benefit Analysis of Grid Development Projects – Draft edition 28 January 2020.
- Directive (EU) 2019/944 of the European Parliament and of the Council of 5 June 2019 on common rules for the internal market for electricity and amending Directive 2012/27/EU.
- Regulation (EU) 2019/943 of the European Parliament and of the Council of 5 June 2019 on the internal market for electricity.
- ACER letter to ENTSO-E and ENTSOG, The Agency's views on a consistent and interlinked electricity and gas market and network model - An opportunity to improve the Ten Year Network Development Plans beyond 2017, 7 June 2016.
- Directive 2014/61/EU of the European Parliament and of the Council of 15 May 2014 on measures to reduce the cost of deploying high-speed electronic communications networks..
- European Commission Joint Research Centre, Guidelines for cost benefit analysis of smart metering deployment, 2012.
- European Commission Joint Research Centre, Guidelines for conducting a cost-benefit analysis of Smart Grid projects, 2012.

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1. Introduction

In 2018, European energy regulators developed guidelines of good practice for incentive schemes that can be used to regulate Distribution System Operators (DSOs). In this 2018 paper[1], the Council of European Energy Regulators (CEER) identified nine common goals for DSO regulation to be considered while taking into account national characteristics. These goals include introducing a holistic view in DSO regulation and ensuring a coordinated Whole System Approach (WSA). This concept was introduced in the 2016 CEER position paper on relationship between Transmission System Operators (TSOs) and DSOs[2].

To adopt a WSA essentially means to consider the societal net benefit for the entire system, in line with the applicable energy policy objectives, and to encourage network operators to consider consequences of their decisions on other actors of the value chain. This is crucial, because when certain incentives or interests only cover specific areas (e.g. a basic layer where a network operator is only interested in its own network activities), results could well be suboptimal.

This report further develops the WSA concept, by describing three possible WSA layers, which should be considered to reach a better (in theory optimal) outcome:

- An integrated view of the regulation of distribution and transmission networks with a main focus on network operation and planning (layer 1 “whole-network-approach”);
- An integration across a sectoral chain (e.g. in electricity or in gas), i.e. expanding beyond networks to for instance, include demand, generation, system operation and retail, both in terms of interaction with network operators and in terms of the impacts on them (layer 2 “whole-chain-approach”);
- An integration across different energy areas, e.g. the integration of regulation of the electricity, gas and heat sectors, including with transport, as mentioned in some responses to the CEER consultation for the 2018 paper on incentive schemes (layer 3 “cross-systems-approach”). This may require coordination among different regulators or other institutions).

The WSA concept and the three layers are visualised in Figure 1.

While all layers are usually addressed at national level, cross-border coordination could be an additional (geographical) feature of the WSA.

[1] CEER Conclusions Paper on Incentives Schemes for Regulating Distribution System Operators, including for innovation, 19 February 2018.

[2] CEER Position Paper on the Future DSO and TSO Relationship, September 2016.

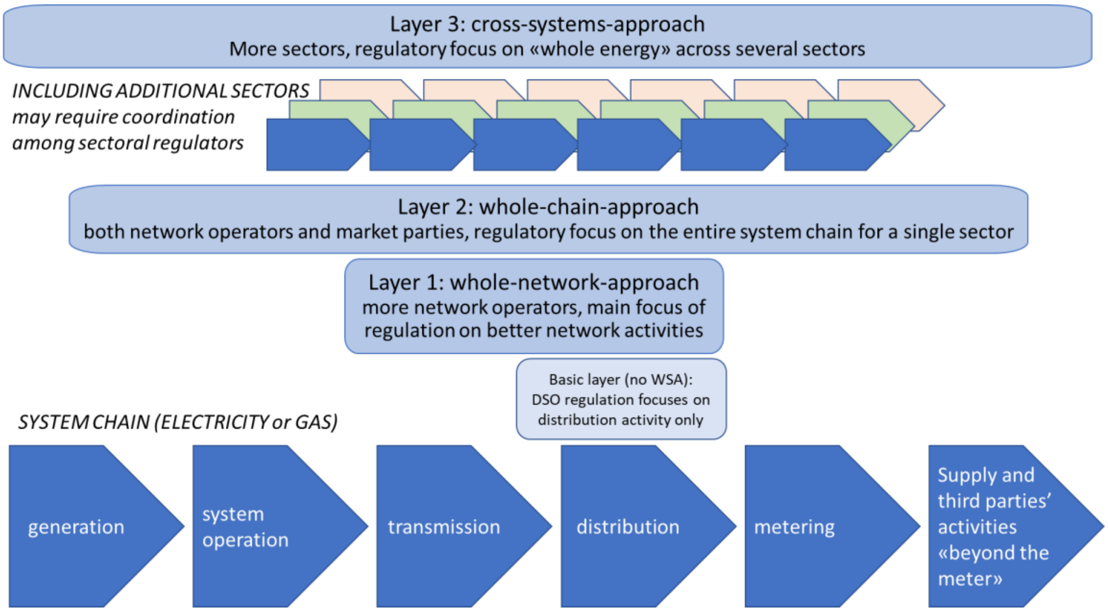

Figure 1 – Different layers of the Whole System Approach

In the remainder of this report, Chapter 2 discusses the expected outcomes of a WSA; Chapter 3 reflects on the levers to make a WSA work; and Chapter 4 derives some conclusions. In Annex 1, we present some examples of WSA applications in national regulations.

2. Expected outcomes of whole system approaches

Energy systems are evolving through technological developments, as well as by political or societal objectives. In the electricity sector, for example, decentralised generation, decentralised storage, and increasingly flexible demand lead to a system wherein electricity flows are not one-directional anymore, and where distribution-connected assets can provide system services traditionally offered by transmission-connected power plants. This fundamental change of the structure of our electricity system, along with an increased interaction between the electricity, gas, heat, and transport sectors creates a need for a more holistic approach to regulation. A WSA to regulation adds a dimension to the traditional approach to regulation, which aims at incentivising the distribution and transmission system operators to optimise only their own system (basic layer).

The WSA always aims to lead to a cost optimum from a societal perspective, but depending on the WSA layer, the expected outcomes can vary. Besides overall cost reduction at a system level, the societal perspective could encompass, for instance, those benefits which are currently being defined in the third edition of the ENTSO-E cost-benefit analysis methodology for transmission projects: more efficient day-ahead market operation, reduction of greenhouse gas and other emissions, reduction of network losses, increase of system adequacy, system flexibility and system stability, lower redispatching costs[3]. Benefits may have a cross-systems nature: some gas infrastructure developments could contribute to fuel switching in the power generation sector and therefore, release benefits in terms of more efficient power market operation.

2.1 Layer 1: Whole-network-approach

A WSA should contribute to reaping the benefits of a better cooperation between DSOs and TSOs or between different DSOs.

In this approach, DSOs and TSOs are expected to optimise the network as a whole, rather than focusing on minimising DSOs' and TSOs' costs separately from each other. A better coordination of incentives between different DSOs and TSOs could bring beneficial outcomes to consumers in the forms of lower network tariffs compared to a scenario without coordination; more efficient market functioning; and/or more reliable electricity supply.

Network operation

With respect to the electricity network, congestion may happen more frequently as a result of an increase in decentralised renewable generation. Distributed resources both increase the possibility of congestion and the possible remedies for it, when activated as flexibility sources. Hence, the energy system is becoming more complex and congestion management processes are expected to evolve.

If this evolution supports coordination and cooperation across network boundaries (and with users of the network), the most efficient solution is more likely to be found and implemented.

Activation of these flexibility sources can cause congestions in connected grids, or multiple and possibly off-setting activations of flexibility in the same area by different operators for

[3] It can be observed that some of these benefits (e.g. increase of system adequacy) already go beyond the "basic layer" (transmission only) and feature a whole-system perspective.

different reasons. A well-coordinated process between TSOs and DSOs is needed to prevent this when designing frameworks to access flexibility (e.g. through timing of gate closure times).

Robust and efficient coordination can reduce the impacts of system disturbances. For instance, a network operator may provide alternative options to reactivate the electricity supply for the users of another operator's network, which were disconnected, as long as proper arrangements and operational coordination are put in place for this purpose.

With respect to the gas network, the shift from natural gas to renewable or low carbon gases will need a more structured coordination between DSOs and TSOs. In particular, the expected increase of decentralised gas production (particularly of biomethane, but also of gas produced from power-to-gas facilities) requires the sharing of data between DSOs and TSOs. Regarding local congestions, a reverse-flow approach from distribution to transmission level may be needed. Moreover, in countries that will choose to replace natural gas with hydrogen in their gas networks, there will be a need for adaptation and/or replacement of gas infrastructure, which requires coordinated actions between DSOs and TSOs.

Network planning

Network operators need to provide sufficient capacity to grid users and clear visibility of any potential development needs of the network. These needs may be driven by future grid congestion, security of supply, the need for integration of distributed resources, loss reduction, voltage stability or voltage quality considerations. A better coordinated approach to network planning might be a way to remove physical constraints to the availability of resources in an economically efficient way.

An investment by a TSO could help, for example, to solve a problem at distribution level at lower cost than alternative distribution investments or vice versa. The regulatory framework should incentivise both parties to agree on the overall cheapest option, even if one of the network operators has, in the end, higher costs. In view of integrating decentralised renewables assets, adequate coordinated network planning and clear visibility of future needs across the entire network are an instrument for decarbonisation at least cost[4]. The electricity distribution network development plans, now legally required in all EU Member States by Directive (EU) 2019/944 for DSOs with more than 100,000 customers, are a tool to increase visibility on network needs and facilitate TSO-DSO and DSO-DSO coordination[5].

2.2 Layer 2: Whole-chain-approach

While the first WSA layer aims to create coordinated incentives across several regulated entities in order to improve the benefit-to-cost balance of the regulated part of the electricity or gas system, the second layer includes repercussions on non-regulated entities. The rationale of the whole-chain-approach is to enable regulated system operators to act in a way that increases the efficiency of markets and allows the integration of new resources that increase overall system efficiency and in turn decreases overall cost for consumers.

[4] 'Decarbonisation at least cost' is the second pillar of the CEER 3D Strategy for 2019 to 2021, the other two pillars are 'digitalisation' and 'dynamic regulation'.
[5] Deepening TSO and DSO relationships is also one of the recommendations in the CEER Conclusions Paper on Dynamic Regulation to Enable Digitalisation of the Energy System, 10 October 2019.

Network operation

Distributed resources may both increase the possibility of congestion and the possible remedies for it, when activated as flexibility sources. Network operators both enable market actors to provide flexibility – by providing the necessary grid capacity and in many cases the necessary data – and source flexibility from market actors, for example for congestion management or, for the electricity sector, frequency or voltage control. The energy system is becoming more complex and congestion management processes are expected to evolve. In the electricity sector, Article 32 of Directive (EU) 2019/944 reflects this by mandating that the regulatory framework needs to provide *"[…] incentives to distribution system operators to procure flexibility services, including congestion management in their areas, in order to improve efficiencies in the operation and development of the distribution system*".

Changing the way network operators procure and use flexibility, for example by including a wider range of actors, or solving constraints otherwise solved by hardware investments through the use of flexibility, generally involves investments, which may initially mean additional cost on the network operator side[6]. However, if these investments allow market players to provide or develop efficient new solutions, they might reduce the overall cost of the system – at least compared to other potential solutions.

If DSOs and TSOs integrate a whole-chain-approach in their decision making, for example in the processes to procure these services, the value customers can derive from different markets, through offering flexibility service is more likely to be optimised, while avoiding double booking of flexibility potential, creating more viable business cases and a more competitive market. This whole-chain-approach can be complemented with better alignment and coordination across DSOs and TSOs (see whole-network-approach above).

Network planning

In the electricity sector, available network capacity has an impact on the ways market players can act in the market. By adopting a whole-chain-approach, network operators are incentivised to proactively take into account the need for grid development, hence, facilitating the deployment of generation assets that reduce overall system cost. To provide information to investors, it is also important to provide visibility on future network development to the market. The network development plans on DSO level, as mandated by Article 32 of Directive (EU) 2019/944 are an important element to create confidence in this context.

In the gas sector, in addition to the deployment of decentralised injections of gas, a WSA is also important in the context of the deployment of hydrogen, which may require not only the adaptation and/or replacement of the gas infrastructures (layer 1 above), but also the adaptation of end-user appliances.

There are synergies between the layer 1 and layer 2 approach to network planning. Coordinated network planning is important for the market as a coordinated planning approach from DSOs and TSOs increases market actor's confidence in the future outlook and provides certainty.

[6] A CEER paper on DSO procedures on procurement of flexibility will be published in Q2 2020.

Data

A whole-chain-approach also considers impacts of DSO investments, which can be beneficial to new business models. A digitalised energy system and energy market enables many – often data driven – new services that can benefit customers[7]. For DSOs and TSOs, however, generating and providing the data that makes such services possible has a cost.

The cost of the digital transformation and other new services provided by network operators is not necessarily efficient if viewed from the operator's own perspective. However, it often has a positive overall societal impact. A WSA to regulation is a tool that can enable network operators to feature these impacts into their decision-making.

In some countries, the WSA principle has been a driver for the deployment of smart metering systems. In Austria, Luxembourg and the Netherlands, to name a few examples, the cost-benefit analysis carried out ahead of the roll-out decision identified benefits in terms of consumer awareness, which could lead to measurable energy efficiency gains[8] [9]. Equally, smart meters enable many new services and new business models, which benefit consumers in ways other than improving grid operation.

2.3 Layer 3: Cross-systems-approach

The need for a WSA has become a key issue in the EU energy and climate policy. Indeed, in its 2020 work programme[10], the European Commission announced that it will adopt a new strategy on smart sector integration (recently renamed as energy systems integration), in the context of the European Green Deal[11].

Sectoral integration aims at a better coordination and linkage of the different areas of the energy system in order to exploit synergies among different energy vectors (in particular electricity and gas) and their different uses (in particular heating and transport). The objective of this strategy, which aims at considering every opportunity to reduce emissions, is to achieve a cost-effective decarbonisation of the EU economy. An aspect of sector integration that attracted much attention is sector coupling, that is the process of fully interconnecting the electricity and gas sectors. CEER has already started work on the topic, with its Bridge Beyond 2025 paper published in 2019, and new related documents to be published in the coming months.

A cross-systems-approach to regulation might be a way to unleash additional flexibility potential for the electricity sector. This may be needed depending on the availability of green electricity in the future. For instance, the flexible operation of power-to-gas plants, power-to-heat assets or vehicle-to-grid infrastructure can provide the needed demand-side flexibility to

[7] A detailed view on both the digitalisation of the energy system and on new services of DSOs is provided in the CEER Conclusions Paper on New Services and DSO Involvement, 22 March 2019.
[8] More generally, the EC JRC 2012 Guidelines for cost benefit analysis of smart metering deployment encompass several benefits at several layers (beyond DSO operations and including consumer and market functioning): reduction of reading costs, reduced costs in future smart grid implementation, reduction of technical losses, network operational efficiencies, energy savings due to consumption feedback, reduction of outage time.
[9] See also the relevant case studies in the CEER Report on Implementing Technology that Benefits Consumers in the Clean Energy for All Europeans Package, 22 July 2019.
[10] See https://ec.europa.eu/info/publications/2020-commission-work-programme-key-documents_en
[11] CEER responded to the European Commission's request for input on this strategy for smart sector integration – find CEER's response here.

match variable production of non-dispatchable renewable assets on the electricity side as well as other benefits in the other sector concerned.

A regulatory framework taking into consideration cross-system impacts, between sectors of which at least one is regulated, can be an efficient means to help the deployment of such technologies at least cost for consumers.

Electricity and gases

In the current system, the electricity and gas sectors already have a strong impact on each other as they are directly linked via gas-fired power plants. The relation between gas and electricity is both at the market level (where we have, on the one side, that electricity demand affects gas demand, and, on the other side, that gas price impacts on the electricity price) and at the network level (as large gas-fired power plants are connected to both electricity and gas transmission networks).

An enhanced cross-system-approach to network planning across electricity and gas sectors could ensure better insight on plausible future scenarios and more efficient planning in each sector. In particular, the development of cross-sectoral scenarios, which is recommended by ACER and CEER[12], is already happening in a few countries.

Given the variability of energy production from renewable sources, there is a potential to store or use electricity that is produced at times of high renewable generation but cannot be used directly as electricity at that time, due to network constraints or low demand. This can be done by converting electricity to gas (to produce for example, synthetic methane or hydrogen) thanks to so called power-to-gas technologies. Power-to-gas installations first produce hydrogen though electrolysis, which can be used in various ways. It can be consumed directly, as an energy vector – for example in fuel cells; it can be injected it into the natural gas grid (up to a certain percentage without need of infrastructure adjustment); or it can be combined with CO_2 to produce synthetic methane or liquid fuels. Power-to-gas is a relatively fast-reacting form of conversion. With this technology, the so-called "sector coupling" between the electricity and gas sectors can be achieved: electrical energy could be converted to the gaseous energy.

The products of power-to-gas are currently not economically competitive. Power-to-gas technologies are being tested in various projects across Europe as a means of providing flexible demand and allowing long-duration energy storage. A cross-systems-approach to regulation would ensure that these flexibility benefits are correctly valued, and that unwanted regulatory barriers to the development of power-to-gas are removed.

Coordination in planning across TSOs and DSOs in both the gas and electricity sectors would give a better understanding about which areas power-to-gas could be deployed in a way that is particularly beneficial to both grids. This information should also be shared with the market. To assess this, it is of utmost importance to have realistic, coordinated scenarios on the availability of renewable energy sources (RES), including in particular, the profile and location of RES generation and its location. The coordinated establishment of such scenarios should be a part of a cross-systems-approach.

[12] ACER 2016 letter on interlinked electricity and gas Ten Year Network Development Plans and CEER Bridge beyond 2025 paper.

If gas DSOs are involved in these projects, regulation must prevent unintended interactions between the regulated and competition-based activities in terms of cost and revenue allocation, and information asymmetry. One way to address this issue could be to replicate the prohibitory approach of Directive (EU) 2019/944 for electricity DSO ownership, development, management and operation of energy storage facilities[13].

Heat

Decarbonisation of the heating sector can be achieved through a variety of different technologies, and the most cost-efficient solution depends of the specific characteristics of each region. Among them, we can list decarbonisation options that are linked to the gas sector, such as the use of biomethane, and others that are linked to the electricity sectors, such as heat pumps and installations of cogeneration of heat and power in district heating. Considering the different decarbonisation options, in order to reach decarbonisation in the most cost-efficient way, it is important to use a WSA that takes into account all costs and benefits of the different possibilities, and their impact on the whole energy sector, including the synergies with other energy areas.

For example, heating may be used as a way of storing energy. There are several potential technologies for heat storage on a seasonal basis[14]. They are not economically viable yet, but they could become so in the future. These technologies can help to bridge the seasonal variations of renewable electricity production. This topic is particularly important for DSOs, because power-to-heat facilities are often connected at the distribution level, as heat cannot easily be transported over long distances, and hence, it is usually stored close to the production and consumption site. For this reason, within a cross-systems regulatory framework that supports joint planning, electricity DSOs could consider the possible needs for additional capacity from the heat sector and would factor in potential benefits of the electrification of heat.

Transport

A second sector that is increasingly integrated with the electricity and gas sector is transport. The "Vehicle to grid" (V2G) opportunity is a first example; electric vehicles (EVs) can provide value not only for mobility but also for the power system, contributing – under a non-discriminatory regime in respect of other flexibility resources – to provide ancillary services. On the mobility side, this opportunity implies that EV owners can reduce the payback time of their investments in EVs, thus further contributing to the decarbonisation of the transport sector.

A further example of integration with the transport sector is given by "infrastructure corridors", i.e. building together highways or (high speed) railways and power lines. Some projects will be operational soon (e.g. ElecLink High Voltage Direct Current (HVDC) through the Channel Tunnel and Italy - France HVDC along the Fréjus motorway) and there are opportunities for new developments, which would likely reduce the local opposition to new power transmission infrastructure. The relevance of energy-transport corridors is also acknowledged by the EU's actions to co-finance these projects. For instance, the 2016 Connecting Europe Facility Synergy call for proposals in the transport and energy sectors supported synergy actions between the transport and energy sector.

[13] Subject to derogations as set out in Article 36 of Directive (EU) 2019/944.
[14] See e.g. https://www.sciencedirect.com/topics/engineering/seasonal-heat-storage

Challenges of a cross-systems-approach

While the aim of applying a WSA across sectors is relatively clear, the regulatory levers are not straightforward. The regulatory tools for a WSA need to be properly designed to avoid the risks of cross-subsidies between sectors and of creating undue incentives for certain technologies. This is also valid for layers 1 and 2, where undue cross-subsidies between grid levels or between networks and markets need to be avoided. Regulators and DSOs/TSOs need to be aware of possible unintended consequences when applying a WSA. The levers are discussed in more detail in chapter 3.

3. The levers to make a Whole System Approach work

As noted above, there are a number of levers that can encourage and enable a WSA, but they can also limit the scope of what is possible. We separate out below types of levers and enablers that can be explored:

3.1 Regulatory incentives

This includes features within network regulation that encourage whole system approaches. In line with Article 18 of Regulation (EU) 2019/943[15] and further measures which may be allowed by national legislation, this can be built in from the beginning of the process. For example, network operators can receive a positive (negative) incentive if they actively (do not) demonstrate a WSA. Or, such features can be embedded within the price control or tariff setting itself, for example where access to innovation funding criteria can include a WSA requirement.

3.2 Regulatory requirements

As already indicated in the ACER-CEER paper "The Bridge Beyond 2025", a sustainable future needs decarbonised gases and new technologies (such as power-to-gas), but the current regulatory framework was not designed with these activities in mind. The potential lack of regulation, or inadequate regulation, for these areas may have unintended consequences, acting as a barrier or hindrance to their development. A cross-systems-approach to regulation would ensure that possible existing unwanted regulatory barriers (e.g. double charging) to the development of new technologies are removed.

There could also be specific regulatory requirements inserted to coordinate and cooperate to achieve a WSA. If the legal framework allows for it, network operators can be directly required to cooperate and coordinate with other operators and/or third parties when a proposed action does not negatively impact their own customers and brings positive benefits to the system as a whole.

3.3 EU and national laws and regulation

Historically, gas and electricity (and other) sectors are usually regulated via separate regulations. This is one of the key challenges in achieving a WSA. The structure of these may at a minimum not encourage network operators to work outside their sector and may go further to also actively limit the ability of regulators or network operators to coordinate outside their sector. There are often very valid reasons for this, including the avoidance of cross-

[15] Article 18(2) of Regulation (EU) 2019/943 Tariff methodologies shall reflect the fixed costs of transmission system operators and distribution system operators and shall provide appropriate incentives to transmission system operators and distribution system operators over both the short and long run, in order to increase efficiencies, including energy efficiency, to foster market integration and security of supply, to support efficient investments, to support related research activities, and to facilitate innovation in interest of consumers in areas such as digitalisation, flexibility services and interconnection.
Article 18(8) Distribution tariff methodologies shall provide incentives to distribution system operators for the most cost-efficient operation and development of their networks including through the procurement of services. For that purpose, regulatory authorities shall recognise relevant costs as eligible, shall include those costs in distribution tariffs, and may introduce performance targets in order to provide incentives to distribution system operators to increase efficiencies in their networks, including through energy efficiency, flexibility and the development of smart grids and intelligent metering systems.

subsidisation. But given the benefits of the WSA, (and other developments[16]) there are positive benefits to be achieved if pathways can be created to work across sectors, whilst keeping to a minimum any potential negative impacts like unjustified cross subsidies.

3.4 Enabler: data transparency and interoperability

Being able to access data and information is a fundamental enabler to facilitate cooperation and coordination. The more that access to data and transparency is facilitated, the more opportunities to take a WSA there will be. Requiring more data transparency and interoperability can be achieved via all the above levers. Better data availability may also reduce the need for specific WSA levers to be employed. For example, a third party could approach a network operator (or a data hub, where applicable) with an opportunity they have identified from receiving more information about a certain issue. That proposal can be so beneficial to a network operator that they would agree to work together without any regulatory requirement.

[16] Other developments also highlight the importance of cross-sector working, for example the development of bundled products, as described in the CEER Guide to Bundled Products, and developing roles of DSOs, as described in the CEER Conclusions Paper on New Services and DSO Involvement.

4. Summary and Conclusions

Electricity systems are evolving through the larger scale deployment of new technologies: decentralised generation, storage, and increasingly flexible demand lead to a system with bidirectional energy flows and system services provided also by distribution-connected assets. Gas systems are also going to evolve and face new challenges, such as decentralised injection of gas. These changes, amongst others, lead to an increased interaction between the electricity, heat, gas and transport sectors, which creates a need for a more holistic approach to regulation.

Since 2016, CEER has advocated that network operators should have a wider vision of the value chain and extend it to the overall network level. As elaborated in this paper, this vision should go even beyond – where societal net benefit for the entire system in scope is the main criterion – rather than limiting this to only the perspective of its own grid. Accordingly, regulators aim for adopting a "whole system approach" to regulation. WSA aims at considering the financial and technical impact of choices of a DSO and/or TSO on other actors and to create a framework wherein the network operator is incentivised to take decisions which lead to a beneficial outcome for the wider system rather than just optimising its own network. At the same time, this approach should not in any case foreclose competition.

With this document, CEER aims to provide more clarity in certain grey areas of WSA, by defining this holistic approach to regulation in three possible layers: "whole-network-approach" (layer 1), "whole-chain-approach" (layer 2) and "cross-systems-approach" (layer 3). These whole system approaches always aim to lead to a cost optimum from a societal perspective, but depending on the WSA layer, the expected outcomes vary.

The first layer, whole-network-approach, addresses the need for better TSO-DSO or DSO-DSO coordination in order to unlock the unexploited grid-related benefits that would mainly be manifested in lower network tariffs and better electricity supply for customers. Robust and efficient TSO-DSO coordination can avoid or reduce congestion or system disturbances. Furthermore, TSO-DSO and DSO-DSO coordination in the process of network planning contributes to the realisation of cost-effective grid reinforcements and decarbonisation at least cost.

The second layer, whole-chain-approach, provides similar benefits as a whole-network-approach, but extends the consideration of impacts to market players (e.g. generators, storage etc.). Available network capacity impacts on the ways market players can act in the market. The impacts of DSO investments can also be beneficial to new business models, for example new, data driven services (e.g. data hubs etc.).

The third layer, a cross-systems-approach to regulation, is a means to unleash additional flexibility potential in the electricity sector and helping to deploy technologies like power-to-gas plants, power-to-heat assets or vehicle-to-grid charging infrastructure at least cost for consumers. However, the cross-systems-approach faces some challenges: the regulatory tools for a WSA need to be properly designed to avoid the risk of cross-subsidies between sectors and of creating undue incentives for certain technologies.

Regulators, DSOs and TSOs need to be aware of possible unintended consequences when applying a WSA. In order to make WSA work, CEER identifies at least four types of levers or enablers that should be considered when applying WSA:

- Setting proper direct or indirect regulatory incentives to encourage the network operators to use WSA;

- Defining specific regulatory requirements for network operators or removing unwanted regulatory barriers that may exist;
- Evolving EU and national laws and regulations in order to create appropriate pathways to work across sectors, whilst keeping to a minimum any potential negative impacts; and
- Improving data transparency and interoperability to facilitate cooperation and coordination and to boost the opportunities to use the WSA.

Although WSA has clear advantages for modern regulation, the analyses performed have put on the table relevant problems for real-world application of this approach. However, the applications of WSA across the EU presented in Annex 1, show that some regulators have already adopted elements of the WSA and that this approach has evolved based on the efficacy assessments of former mechanisms. Learnings from real-world applications may encourage National Regulatory Authorities (NRAs) to explore the mechanisms of WSA and adopt it to the extent that those decisions are within the scope of the NRA’s responsibilities in each country.

5. Annex 1 – Case studies

5.1 WSA based incentives for DSO/TSO in Slovenia

The presence of innovation is a key element of today's regulatory frameworks – in this perspective, Energy Agency, the Slovene energy regulator, has incentivised the investments in smart grids for several years. Energy Agency has been continuously evolving the incentive scheme for innovations for the last three consecutive regulatory periods addressing the first two layers of WSA complexity (excluding cross-sector perspective).

As early as the 2013-2015 regulatory period, the Energy Agency had started to incentivise the use of some of the WSA key features by the DSO and TSO (e.g. positive cost benefit analysis (CBA) based on societal net benefits, optimised network operation by both distribution and transmission grids) within its direct incentive scheme that targeted the investments in smart grids with investment costs exceeding 200,000 EUR. In the 2016-2018 regulatory period, the incentive scheme for qualified innovative investments was refined and upgraded based on existing WSA pillars (besides changed definitions, the financial incentive was increased). Finally, following the internal impact assessment, the incentive scheme was further refined and upgraded with an output-based approach for the regulatory period 2019-2021. In addition, the consideration of additional WSA features by DSO/TSOs is incentivised by additional financial rewards.

The incentive scheme based on the WSA is applied on qualified investment projects (excluding assets financed by non-refundable funds) for the current regulatory period under following terms of reference:

- Investment costs exceeding 100,000 EUR;
- Consistency with standardised definitions of smart grids and smart grid infrastructure; and
- Directed to solving the problem in at least one of the defined ten target application domains.

Qualified projects may be granted following time limited financial incentives for extra return:

- Basic incentive: 2% of the current value of the asset as at 31 December for a period of three consecutive years from the year in which the asset was put into service;
- WSA-based incentive: additional 3% of the current value of the asset as at 31 December for a period of three consecutive years from the year in which the asset was put into service *if the DSO/TSO proves that it used the WSA approach in the design and implementation of the solution*:
    - As verification in the application process, the DSO and TSO shall submit a joint statement on cooperation in the planning and implementation of the investment, with a detailed justification stating that the investment uses the most efficient solution design for the entire electricity system. The investment must provide an effective coordination mechanism between the DSO and TSO, which includes also the effective real-time data interchange on the important state of the distribution system (less than 30 seconds; e.g. observability of distributed energy resources). The justification must be provided based on the evaluation of one or more key performance indicators (KPI) addressing the WSA approach that may supplement the set of indicators from the list referred to in the "Guidelines for conducting a cost-benefit analysis of Smart Grid projects", Report EUR 25246 EN - Annex IV.

- Output based incentive: a one-time financial incentive (reward) in the amount of 5% of the costs of acquiring the assets for improving performance (ΔKPI > 0; whereas ΔKPI represents a difference between the KPI calculated after the innovative measure is in place and the KPI calculated based on initial state) based on defined set of KPI determining the target domains of innovative action.

The sum of all incentives granted is capped by 10% of project net benefits (output-based incentive cap). An additional incentive is provided by the specific treatment of operating expenditures (OPEX), which relates to the assets of qualified smart grid projects as pass through costs in the regulatory procedure for granting the deviations from planned costs. There are no requirements on cost efficiency applied on these costs, so the treatment is equivalent to the uncontrolled OPEX cost category (the costs which cannot be influenced by the system operators). Another cost category, defined controlled OPEX with applied requirements on cost efficiency, remains unchanged through the regulatory period and it is not adjusted to the actual realisation. Both cost categories are determined based on historical realisation and eligibility criteria.

The precondition for qualification for such innovative actions is a positive CBA based on societal net benefits – such investments can therefore result in also in explicit benefits for consumers (e.g. lower network tariffs).

In 2018, project SINCRO.GRID[17] (https://www.sincrogrid.eu/) has been qualified for the basic incentive. The application for a WSA-based incentive is expected in 2020. At the time of publishing this paper, the project is on-going and is in the phase of upgrading the existing infrastructure, therefore the estimation/quantification of benefits was not yet possible.

5.2 Case study from Great Britain

In 2017, the gas and electricity regulator for Great Britain, Ofgem, and the UK government jointly published a "Smart Systems and Flexibility Plan"[18]. In this, the importance of the need for whole systems coordination and cooperation was recognised. This document tasked the network companies, through reputational levers, to work together to deliver mechanisms for transmission and distribution coordination that enable whole system network requirements to be identified and acted upon efficiently, in the best interests of consumers (Layer 1).

The Energy Networks Association (ENA) initiated the Open Networks Project, to address the tasks given to them in the Smart Systems Plan. The members include all network companies and the Electricity System Operator. The project consists of a number of work programmes that seek to achieve coordination across different areas, including planning, data sharing, valuation of flexibility, and alignment of flexibility products. Planning outputs include common building blocks when developing future scenarios and standardised terminology and communication channels to facilitate sharing information. The standardisation of flexibility products being tendered and alignment in procurement contracts are examples where coordination across network companies can help facilitate the growth of flexibility markets, as it is easier for potential providers to understand and enter the markets. There are structures

[17] The project goals comprise effective integration of dispersed RES into electricity systems of Slovenia and Croatia, improvement of voltage quality, increasing the possibilities for the inclusion of ancillary services and capacities of existing transmission lines and improving the observability of transmission and distribution systems by using an innovative integration of mature technologies.

[18] https://www.gov.uk/government/publications/upgrading-our-energy-system-smart-systems-and-flexibility-plan

for stakeholders to feed into the development of the work, and also provide comment on the outputs. Ofgem will be reviewing key outputs from this project and considering whether and how to embed products into the regulatory structure, where required.

Alongside this, Ofgem is consulting on changing the licences of network operators to clarify the regulator's expectations of how they expect network operators to act, as they manage networks efficiently. They set out that, as the environment within which network operators evolves, so too must network and system operators evolve. Given the changes in the system from digitalisation, decarbonisation and decentralisation, Ofgem believes that network operators can only deliver a more efficient and cost effective electricity system for customers if they coordinate and cooperate with each other and third parties. Ofgem is proposing an outcomes-based licence condition that would require network operators to coordinate and cooperate with other distribution licensees and transmission licensees to identify actions and processes that advance the efficient and economical operation of their networks; and also consider actions proposed by system users that seek to advance the efficient and economical operation of the system. Licence holders would need to ensure that any proposals and arrangements put in place do not adversely impact customers in their own area and are in the interests of the whole electricity system (Layer 2). As part of this proposed requirement, Ofgem is setting out that they expect the network companies to make available all relevant data to assist other licence holders and third parties to identify potential opportunities, and also publish updates on what they have done as a result of the licence condition. Ofgem is also further exploring whether they need to require the publication of additional data by network operators.

Ofgem is also in the process of establishing the framework for the next round of price controls for the monopoly operators. They consulted on how to incentivise or otherwise encourage whole systems actions, including actions that are cross-system (Layer 3). The total expenditures (TOTEX) Incentive Mechanism already provides a good incentive for network companies to seek out the most efficient activities. However, where those activities may lie on or across another network, or be in the control of a third party, Ofgem recognised a need for additional mechanisms to enable the transfer of responsibility for the work, along with any associated funding and output-linked incentives. They are developing a common process mechanism to allow this to happen. Ofgem will also be including a whole systems element into the Business Plan Incentive to encourage plans for the next price control to embed a behavioural change across all sectors, encouraging them to identify and implement more efficient solutions by interaction across the whole system.

5.3 Three types of WSA-based incentives for DSOs in Italy

Since 2010, the Italian energy regulator, ARERA, has been adopting incentive mechanisms to ensure appropriate monetary rewards when DSOs manage distribution systems according to the WSA. This applies to each of the 3 WSA layers. In all cases, the rationale for such incentive mechanisms is that DSOs are remunerated for an improvement at wider level than distribution network only. The amount of additional remuneration is usually a portion of the estimated net benefit at system level.

5.3.1 Layer 1 "whole-network-approach": "mitigation service"

Electricity DSOs can contribute to mitigating the impact on final customers of interruptions that originate in the transmission grid under a so-called "mitigation service". This is possible because medium voltage (MV) networks are designed in a redundant manner that allows for back-feeding of customers when a TSO/DSO connection is out of service. Mitigation implies a change in the configuration of the MV network that can be operated remotely by each DSO. Since 2010, the mitigation service is paid to DSOs within the transmission output-based regulation, which is aimed at reducing energy not supplied (ENS) originating in the transmission grid. The transmission incentive regulation recognises the value of DSOs actions to reduce problems that occurred in the transmission network and requires the TSO to pay DSOs when they reduce total ENS of those interruptions.

5.3.2 Layer 2 "whole-chain-approach": observability of distributed generation

From 2016 to 2019, electricity DSOs were incentivised if, on a voluntary basis, they provided real-time data (every 20 seconds) on the state of generation units directly connected to MV networks to the TSO. In this case the DSO received a reward (through a tariff component) because of the benefit that this information provides to the system operator (thereby allowing the TSO to reduce procuring reserves). This innovative functionality was formerly tested in small-scale pilot projects promoted by the regulator. During 2010-2015, it was incentivised via an extra-WACC (Weighted Average Cost of Capital) premium. In 2016 the functionality was confirmed on a large scale (subject to local penetration of RES) by introducing an output-based mechanism. The incentive was dismissed in 2020, because it was a first, preliminary solution to the problem of RES observability in MV networks, for which new solutions, under a mandatory approach instead of a voluntary one, are currently under consultation in Italy.

5.3.3 Layer 3 "cross-systems-approach": sharing the telecom infrastructure of gas smart metering

In 2014, ARERA promoted some pilot projects to test sharing among different public services (e.g. water, waste management, mobility and parking, air quality and noise, etc.), the communication infrastructure (in radiofrequency at 169 MHz) and the information systems developed by gas DSOs to roll out gas smart metering. The pilot projects demonstrated the technical feasibility of this shared architecture that allows for reducing the unitary cost for each service in comparison with a single-sector dedicated solution. In pilot projects the shared architecture was developed and managed by a "third agent", which distributed metering data to the gas distribution operator as well as to other utilities involved in the pilot (e.g. water operator, waste collector, parking operator, etc.). Findings and results from the pilot projects have been publicly disseminated. To favour a broad sharing of the communication infrastructure of gas smart metering across sectors, ARERA recently decided – as a derogation to the ordinary regulation – not to apply any profit sharing to the revenues of gas DSOs that on their own initiative allow utilities of other sectors to use the communication infrastructure of gas DSOs for a contractually-based fee.

5.4 Layer 3 "cross-systems-approach": sharing the electricity distribution infrastructure with telecom operators – an example from Portugal

In 2017, Portugal transposed EU Directive 2014/61 into national law, through Decree-law 92/2017, from 31 July. This Directive aims to facilitate and incentivise the deployment of high-speed electronic communications networks by reducing its cost. One of the main areas of focus concerns measures related with the sharing and re-use of existing physical infrastructure (e.g. ducts, poles or masts), including those belonging to energy and other utilities.

Therefore, the electricity DSOs must share their network infrastructure with telecom companies, in exchange for a fee. According to the legal framework in place, the telecommunications and the energy NRAs must work together to design the methodology to define the adequate remuneration for such services.

While this process is still not finalised, and even though the DSOs are obliged by law to share such infrastructure (it is not due to any regulatory incentives or policies), the need to incorporate both systems (telecommunications and electricity) into regulatory decisions has raised some challenges. From an energy regulator standpoint, these challenges have been twofold. Firstly, when defining the fee payable to the electricity DSOs, ERSE, the Portuguese energy NRA, wants to avoid cross-subsidisation between sectors, aiming to ensure that electricity consumers are not subsidising telecommunications ones. As mentioned in this paper, the regulatory tools for a WSA need to be properly designed to avoid the risk of cross-subsidies between sectors.

Another challenge for the energy regulator is defining the portion of such remuneration that the DSOs should then share with electricity consumers. ERSE has decided that such fee should be fully returned to electricity consumers.

Annex 2 – List of abbreviations

Term	Definition
ACER	European Union Agency for the Cooperation of Energy Regulators
CBA	Cost benefit analysis
CEER	Council of European Energy Regulators
DSO	Distribution System Operator
ENS	Energy not supplied
ENTSO-E	European Network of Transmission System Operators for Electricity
EVs	Electric vehicles
HVDC	High Voltage Direct Current
KPI	Key performance indicators
MV	Medium voltage
NRAs	National Regulatory Authorities
OPEX	Operational expenditure
RES	Renewable energy sources
TOTEX	Total expenditures
TSO	Transmission System Operator
V2G	Vehicle to grid
WSA	Whole System Approaches

Annex 3 – About CEER

The Council of European Energy Regulators (CEER) is the voice of Europe's national energy regulators. CEER's members and observers comprise 39 national energy regulatory authorities (NRAs) from across Europe.

CEER is legally established as a not-for-profit association under Belgian law, with a small Secretariat based in Brussels to assist the organisation.

CEER supports its NRA members/observers in their responsibilities, sharing experience and developing regulatory capacity and best practices. It does so by facilitating expert working group meetings, hosting workshops and events, supporting the development and publication of regulatory papers, and through an in-house Training Academy. Through CEER, European NRAs cooperate and develop common position papers, advice and forward-thinking recommendations to improve the electricity and gas markets for the benefit of consumers and businesses.

In terms of policy, CEER actively promotes an investment friendly, harmonised regulatory environment and the consistent application of existing EU legislation. A key objective of CEER is to facilitate the creation of a single, competitive, efficient and sustainable Internal Energy Market in Europe that works in the consumer interest.

Specifically, CEER deals with a range of energy regulatory issues including wholesale and retail markets; consumer issues; distribution networks; smart grids; flexibility; sustainability; and international cooperation.

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More information is available at www.ceer.eu.